the benefits of individual blade control (IBC) for noise and vibration reduction, and for performance improvement.

The LRTA is a wind-tunnel test stand designed for testing helicopter and tilt rotors up to 50,000 pounds of thrust and 6,000 horsepower. Developed jointly by NASA and the U.S. Army, the LRTA provides unique operational capabilities. These include the ability to measure both steady and oscillatory rotor hub loads using a five-component balance and instrumented flex-coupling, and to provide conventional collective and cyclic pitch control, as well as dynamic high-frequency blade-pitch control.

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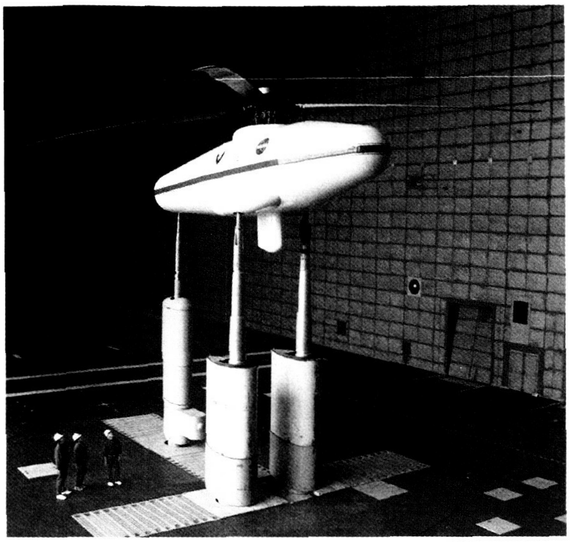

Fig. 1. Large Rotor Test Apparatus in the Ames 80- by 120-Foot Wind Tunnel.

V-22 Tilt Rotor Aeroacoustics

Megan S. McCluer, Jeff L. Johnson, Larry A. Young

The Full-Span Tilt Rotor Aeroacoustics Model (TRAM) is a nominal quarter-scale representation of the V-22 aircraft. The main objectives of the Full-Span TRAM are to investigate aeromechanics of tilt rotors, provide a comprehensive database for validating tilt-rotor analyses, and to support future tilt-rotor designs. It is a dual-rotor-powered model with extensive instrumentation for measurement of structural and aerodynamic loads unique to tilt rotors. Helicopter data trends cannot properly be extrapolated to proprotors or tilt-rotor wakes because tilt-rotor blade geometry and aerodynamic behavior are significantly different. The TRAM, having the first dynamic pressure-instrumented tilt-rotor blades, will provide the only available unsteady air loads data set that can validate tilt-rotor computational codes and will likely be used for many years.

The TRAM is a unique tilt-rotor research platform and a heavily instrumented wind-tunnel test stand. Rotor structural loads are monitored and recorded for safety of flight and for information on blade dynamic behavior. Left and right rotor balance and fuselage balance loads are monitored for safety of flight and for analysis of vehicle and rotor performance. Static pressure taps on the wing can be used to determine rotor/wing interactional effects. Rotor blade dynamic pressures and acoustics are recorded to determine the relationship between air loads and rotor noise magnitude and directivity. Tilt-rotor wake measurements also provide information about noise generation and propagation and can be used to improve computational wake models and noise predictions. Laser light sheet (LLS) flow visualization and particle image velocimetry (PIV) flow measurements describe the wake geometry. All of these measurements will make the Full-Span TRAM database a unique and valuable asset with which computational codes can be validated and future designs can be compared.

The Full-Span TRAM was tested in Ames Research Center's 40- by 80-Foot Wind Tunnel from October through December 2000. Figure 1 is a photograph of the model installed in the test section. Rotor and vehicle performance measurements were taken in addition to wing pressures, acoustics, and flow visualization. Hover, forward flight, and airframe aerodynamic runs were performed. Helicopter-mode data were acquired during angle-of-attack and thrust sweeps for a variety of tunnel speeds and model configurations. Nondimensional performance data were acquired for three different tunnel speeds and for four different rotor-tip-path plane angles. Laser light sheet photographs suggest dual-tip vortex formation at low thrust conditions as shown in figure 2. Data from the Full-Span TRAM test will be compared with previously acquired isolated-rotor TRAM data. These results have implications for future tilt-rotor designs and will be shared with U.S. rotorcraft companies. Additional tilt-rotor aeromechanics testing using the TRAM is planned in collaboration with industry.

The Full-Span TRAM has been established as a valuable national asset for collaborative tilt-rotor research. Comprehensive data reduction and analysis of the 40- by 80-Foot Wind Tunnel test results will continue. Boeing and the Defense Advanced Research Projects Agency (DARPA) are sponsoring additional testing of the TRAM in the Ames 80- by 120-Foot Wind Tunnel in late 2001.

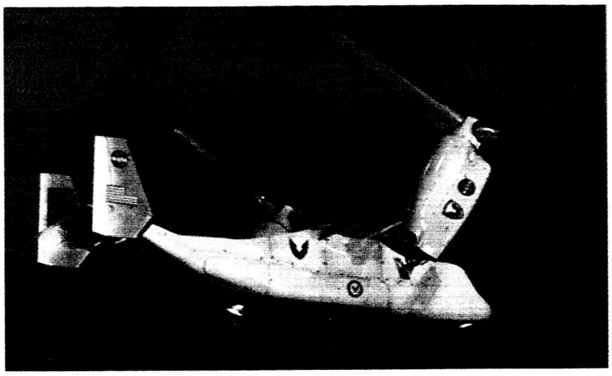

Fig. 1. The Full-Span Tilt Rotor Aeroacoustic Model (TRAM) in the Ames 40- by 80-Foot Wind Tunnel.

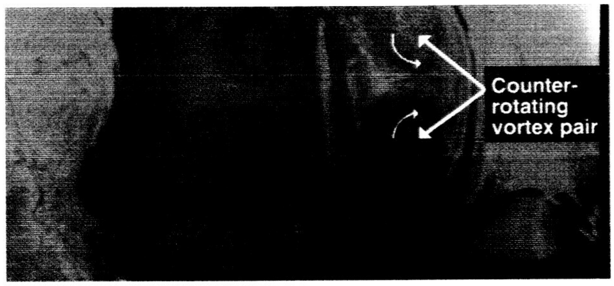

Fig. 2. Full-Span Tilt Rotor Aeroacoustic Model (TRAM) wake investigation (view from behind left rotor looking upstream at advancing blade). Negative tip loading produces counterrotating vortex pair, (CT = 0.009, Advance Ratio = 0.15).

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